

*Zhu*  
*AF#*

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Patricia B. Smith, et al.

Art Unit: 2818

Serial No.: 09/975,639

Examiner: Quoc D. Hoang

Filed: 10/11/01

Docket: TI-29811

For: HYDROGEN PLASMA PHOTORESIST STRIP AND POLYMERIC RESIDUE  
CLEANUP PROCESS FOR LOW DIELECTRIC CONSTANT MATERIALS

Commissioner of Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

MAILING CERTIFICATE UNDER 37 C.F.R. §1.8(a)  
I hereby certify that the above correspondence is being  
deposited with the U.S. Postal Service as First Class Mail in an  
envelope addressed to: MS Appeal Brief Patents, Commissioner  
for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

*Karen Vertz*  
Karen Vertz

*2-14-05*  
Date

Transmitted herewith is an Appeal Brief in the above-identified application. The  
Commissioner is hereby authorized to charge the **\$500.00** fee for this appeal, or credit  
any overpayment to Account No. 20-0668. A duplicate copy of this sheet is enclosed.

Respectfully submitted,

*Rose Alyssa Keagy*  
Rose Alyssa Keagy  
Registration No. 35,095

Texas Instruments, Incorporated  
P. O. Box 655474 - M/S 3999  
Patent Department  
Dallas, Texas 75265



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of: Smith et al.

Docket No.: TI-29811

Serial No.: 09/975,639

Art Unit: 2818

Filed: 10/11/01

Examiner: Hoang, Quoc

Title: Hydrogen Plasma Photoresist Strip And Polymeric Residue Cleanup Process For Low Dielectric Constant Materials

**APPELLANTS' BRIEF UNDER 37 CFR §1.192**

February 14, 2005

Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450

Dear Sir:

**MAILING CERTIFICATE UNDER 37 C.F.R. §1.8(A)**

I hereby certify that the above correspondence is being deposited with the U.S. Postal Service on 2-14-05 as First Class Mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Karen Vertz  
Karen Vertz

2-14-05  
Date

Pursuant to the Office Action mailed 10/01/2004, the Appellants submit this Appellants' Brief. The Commissioner is hereby requested and authorized to charge any fees necessary for the filing of the enclosed papers to the deposit account of Texas Instruments Incorporated, Account No. 20-0668.

02/18/2005 MAHME1 00000045 200668 09975639

01 FC:1402 500.00 DA

### **REAL PARTY IN INTEREST**

The real party in interest is Texas Instruments Incorporated, a Delaware corporation.

### **RELATED APPEALS AND INTERFERENCES**

No related appeals or interferences are known to the Appellants.

### **STATUS OF CLAIMS**

Claims 1, 5-13, 30-39 and 60-68 are the subject of this appeal. Claims 1, 5-13, 30-39 and 51-68 are pending; Claims 51-59 stand allowed, and Claims 1, 5-13, 30-39 and 60-68 are rejected.

### **STATUS OF AMENDMENTS**

The Appellants filed an amendment under 37 C.F.R. § 1.111 on December 20, 2002 in response to the office action dated September 24, 2002. Then the

Appellants filed a second amendment under 37 C.F.R. § 1.111 on June 6, 2003 in response to the office action dated March 14, 2003.

The Appellants filed an amendment under 37 C.F.R. § 1.116 on October 22, 2003 in response to the final action dated August 25, 2003. The Appellants subsequently received an Advisory Action dated November 24, 2003. A Request for Continued Examination was filed by the Appellants on November 21, 2003.

The Appellants filed another amendment under 37 C.F.R. § 1.111 on July 1, 2004 in response to the office action dated March 1, 2004. This amendment did not contain any proposed claim changes.

A Notice of Appeal was filed on December 23, 2004 by the Appellants in response to the final action dated October 1, 2004.

## **SUMMARY OF THE INVENTION**

Independent Claim 1 is directed to a method of fabricating an electronic device on a semiconductor wafer (page 4 lines 2-4 and 13-19, FIGS. 1 and 3). The method comprises forming a layer of a first material in a fixed position relative to the wafer (page 7 lines 21-26, FIG. 2a), wherein the first material has a dielectric

constant less than 3.6 (page 4 line 4, page 8 lines 1-2, page 15 lines 13-15 and 25-26). A photoresist layer is formed in a fixed position relative to the layer of the first material (page 8 lines 7-8, FIGS. 1 and 2b). At least one void is formed through the layer of the first material in response to the photoresist layer (page 8 lines 16-17, FIGS 1 and 2c), thereby forming a polymeric residue in response to the photoresist layer (page 8 lines 20-27). The semiconductor wafer is subjected to a plasma which incorporates a gas which includes hydrogen so as to remove the photoresist layer (page 9 lines 11-14 and 19-21, FIGS. 1 and 2d). Then the polymeric residue is removed (page 10 lines 8-11, FIG. 1). The step of removing the polymeric residue comprises subjecting the semiconductor wafer to a wet etch chemistry (page 10 lines 11-12) and also subjecting the semiconductor wafer to a plasma annealing step (page 11 lines 13-14, FIG. 1).

Claim 5 is dependent on Claim 1 and further specifies that the plasma annealing step comprises subjecting the semiconductor wafer to a plasma which incorporates a mixture of hydrogen and nitrogen (page 11 lines 17-19).

Claim 6 is dependent on Claim 5 and further specifies that the mixture includes no more than 40% nitrogen (page 11 lines 19-21).

Claim 7 is dependent on Claim 1 and further specifies that the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a combination of dilute hydrofluoric acid and an organic acid (page 10 lines 12-27).

Claim 8 is dependent on Claim 7 and further specifies that the organic acid comprises dilute citric acid (page 10 lines 13-19).

Claim 9 is dependent on Claim 8 and further specifies that the dilute citric acid is diluted with deionized water at a ratio between 1:50 to 1:250 (page 10 line 18).

Claim 10 is dependent on Claim 7 and further specifies that the organic acid comprises dilute acetic acid (page 10 lines 21-23).

Claim 11 is dependent on Claim 8 and further specifies that the dilute acetic acid is diluted with deionized water at a ratio on the order of 1:200 (page 10 line 22).

Claim 12 is dependent on Claim 7 and further specifies that the organic acid comprises oxalic acid (page 10 lines 23-24).

Claim 13 is dependent on Claim 7 and further specifies that the dilute hydrofluoric acid is diluted with deionized water at a ratio between 1:500 to 1:1,000 (page 10 lines 15-16).

Independent Claim 30 is directed to a method of fabricating an electronic device on a semiconductor wafer (page 4 lines 2-4 and 13-19, FIGS. 1 and 3). The method comprises forming a layer of a first material in a fixed position relative to the wafer (page 7 lines 21-26, FIG 2a), wherein the first material is reactive with oxygen plasma (page 14 lines 10-11). A photoresist layer is formed in a fixed position relative to the layer of the first material (page 8 lines 7-8, FIGS. 1 and 2b). At least one void is formed through the layer of the first material in response to the photoresist layer (page 8 lines 16-17, FIGS. 1 and 2c), wherein the step of forming at least one void further forms a polymeric residue in response to the photoresist layer (page 8 lines 20-27). The semiconductor wafer is subjected to a plasma which incorporates a gas which includes hydrogen so as to remove the photoresist layer (page 9 lines 11-14 and 19-21, FIGS 1 and 2d). Then the polymeric residue is removed by subjecting the semiconductor wafer to a wet etch chemistry (page 10 lines 11-12).

Claim 31 is dependent on Claim 30 and further specifies that the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a combination of dilute hydrofluoric acid and an organic acid (page 10 lines 12-27).

Claim 32 is dependent on Claim 31 and further specifies that the organic acid comprises dilute citric acid (page 10 lines 13-19).

Claim 33 is dependent on Claim 31 and further specifies that the organic acid comprises dilute acetic acid (page 10 lines 21-23).

Claim 34 is dependent on Claim 31 and further specifies that the organic acid comprises dilute oxalic acid (page 10 lines 23-24).

Claim 35 is dependent on Claim 30 and further specifies that the hydrogen is provided from a hydrogen source selected from a group consisting of  $H_2$ ,  $NH_3$ ,  $N_2H_2$ ,  $H_2S$ , and  $CH_4$  (page 9 lines 21-22).

Claim 36 is dependent on Claim 30 and further specifies that the gas comprises a mixture of gases (page 9 line 19 through page 20 line 3), and the mixture includes at least 50% hydrogen (page 9 line 20).



Claim 37 is dependent on Claim 36 and further specifies that the mixture of gases further includes a diluent (page 9 lines 22-25).

Claim 38 is dependent on Claim 37 and further specifies that the diluent is selected from a group consisting of nitrogen, argon, helium, neon, and xenon (page 9 lines 23-24).

Claim 39 is dependent on Claim 37 and further specifies that the diluent comprises nitrogen (page 9 lines 23 and 26), and the mixture comprises 20% or less of the nitrogen (page 9 lines 26-28).

Independent Claim 60 is directed to a method of fabricating an electronic device on a semiconductor wafer (page 4 lines 2-4 and 13-19, FIGS. 1 and 3). The method comprises forming a layer of a first material in a fixed position relative to the wafer (page 7 lines 21-26, FIG. 2a), wherein the first material has a dielectric constant less than 3.6 (page 4 line 4, page 8 lines 1-2, page 15 lines 13-15 and 25-26). A photoresist layer is formed in a fixed position relative to the layer of the first material (page 8 lines 7-8, FIGS. 1 and 2b). At least one void is formed through the layer of the first material in response to the photoresist layer (page 8 lines 16-17, FIGS 1 and 2c), thereby forming a polymeric residue in response to the photoresist layer (page 8 lines 20-27). The semiconductor wafer is subjected to a plasma which incorporates a gas which includes hydrogen so as to remove the photoresist layer (page 9 lines 11-14 and 19-21, FIGS. 1 and 2d). Then the polymeric residue is removed (page 10 lines 8-11, FIG. 1). The step of removing the polymeric residue comprises subjecting the semiconductor wafer to a wet etch chemistry (page 10 lines 11-12).

Independent Claim 61 is directed to a method of fabricating an electronic device on a semiconductor wafer (page 4 lines 2-4 and 13-19, FIGS. 1 and 3). The method comprises forming a layer of a first material in a fixed position relative to the wafer (page 7 lines 21-26, FIG. 2a), wherein the first material has a dielectric constant less than 3.6 (page 4 line 4, page 8 lines 1-2, page 15 lines 13-15 and 25-26). A photoresist layer is formed in a fixed position relative to the layer of the first material (page 8 lines 7-8, FIGS. 1 and 2b). At least one void is formed through the layer of the first material in response to the photoresist layer (page 8 lines 16-17, FIGS 1 and 2c). The semiconductor wafer is subjected to a plasma which incorporates a gas which includes a diluent (page 9 lines 22-25) and at least 50% hydrogen (page 9 lines 19-21) so as to remove the photoresist layer (page 9 lines 11-14 and 19-21, FIGS. 1 and 2d).

Claim 62 is dependent on Claim 61 and further specifies that the hydrogen is provided from a hydrogen source selected from a group consisting of  $H_2$ ,  $NH_3$ ,  $N_2H_2$ ,  $H_2S$ , and  $CH_4$  (page 9 lines 21-22).

Claim 63 is dependent on Claim 61 and further specifies that the diluent is selected from a group consisting of nitrogen, argon, helium, neon, and xenon (page 9 lines 23-24).

Claim 64 is dependent on Claim 61 and further specifies that the diluent comprises nitrogen (page 9 lines 23 and 26), and the mixture comprises 20% or less of the nitrogen (page 9 lines 26-28).

Claim 65 is dependent on Claim 61 and further specifies that the gas includes approximately 80%  $\text{NH}_3$  and 20%  $\text{N}_2$  (page 10 line 3).

Claim 66 is dependent on Claim 61 and further specifies that the first material comprises a carbon containing oxide (page 7 lines 26-27).

Claim 67 is dependent on Claim 61 and further specifies that the first material comprises fluorinated silicon glass (page 15 line 13).

Claim 68 is dependent on Claim 61 and further specifies that the first material has a dielectric constant less than 2.8 (page 8 lines 1-2).

## **ISSUES**

1. Whether Claims 30 and 60 are anticipated under 35 U.S.C. §102(e) by the patent granted to Kropewnicki et al. (U.S. Pat. No. 6,440,864).

2. Whether Claims 1, 5-13 and 31-39 are unpatentable under 35 U.S.C. §103(a) over the patent granted to Kropewnicki et al. (U.S. Pat. No. 6,440,864) in view of the patent granted to Torek et al. (U.S. Pat. No. 6,562,726).

3. Whether Claims 36-39 are unpatentable under 35 U.S.C. §103(a) over the patents granted to Kropewnicki et al. (U.S. Pat. No. 6,440,864) and Torek et al. (U.S. Pat. No. 6,562,726) as applied to Claim 30, and further in view of the patent granted to Hillyer et al. (U.S. Pat. No. 6,613,681).

4. Whether Claims 61-68 are unpatentable under 35 U.S.C. §103(a) over the patent granted to Kropewnicki et al. (U.S. Pat. No. 6,440,864) in view of the patent granted to Hillyer et al. (U.S. Pat. No. 6,613,681).

### **GROUPING OF CLAIMS**

Claims 1, 5-13, 30-39 and 60-68 stand separately.

## ARGUMENT

**Issue 1 - Whether Claims 30 and 60 are anticipated under 35 U.S.C. §102(e) by the patent granted to Kropewnicki et al. (U.S. Pat. No. 6,440,864).**

Claim 30 positively recites the step of removing the polymeric residue by subjecting the semiconductor wafer to a wet etch chemistry. These advantageously claimed features are not taught or suggested by the patent granted to Kropewnicki et al. The Appellants submit that Kropewnicki et al. teaches a plasma clean process (column 2 lines 1-44); but not a wet clean process in a low-k dielectric environment as advantageously claimed.

The Appellants respectfully traverse the statement in the Office Action (page 3) that Kropewnicki et al. teaches the use of wet etch chemistry for removing the polymeric residue. Kropewnicki et al. teaches away from the use of wet cleans (col. 1, lines 48-58) while teaching the use of a dry clean process (col. 1, line 66 through col. 2, line 44). More specifically, Kropewnicki et al. considers the wet clean process undesirable; stating (column 1 lines 44-57) that the wet clean process requires a solvent that is costly and hazardous to the environment, contributes to lower yield because the substrate is contaminated in the transferring operation, and oxidizes contact/junction points. Furthermore, the

Appellants submit that the EKC 265 solvent listed in the cited portion of the Kropewnicki et al. patent (e.g. column 1 line 46) is not capable of removing the polymeric residue on the first material of Claim 30. Specifically, the MSDS for EKC 265 reveals that it contains 2-(2-Aminoethoxy) ethanol plus hydroxylamine plus catechol. Therefore, EKC 265 is very inferior to the advantageously claimed mixture at removing the type of polymer found on wafers after dielectric etch and resist removal.

In addition, the Appellants submit that  $\text{NH}_3$  is used in Kropewnicki et al. as a gas component of a plasma process (column 8 line 55 through column 9 line 16). Specifically, the Kropewnicki et al. patent describes the use of  $\text{NH}_3$  gas in a plasma as an additive to a mostly  $\text{O}_2$  plasma for resist and residue removal (column 8 line 59 through column 9 line 2). There is no teaching of using a wet process in the Kropewnicki et al. patent.

The Appellants note that Kropewnicki et al. describes the use of an etching chamber to remove the photoresist and post etch and ash polymeric residues (i.e. col. 2, lines 36-44). In addition, Kropewnicki et al requires biasing of the wafer (col. 2, line 22). The Appellants submit that the Kropewnicki et al. process produces substantial damage to low-k dielectric material. The Appellants downstream plasma tool (page 9 lines 13 – 17) operates in a completely different regime that

includes higher process pressure, much higher gas flows, much higher temperatures, and no biasing of the wafer.

For these reasons, the Appellants respectfully assert that Claim 30 is patentable over Kropewnicki et al.

Claim 60 positively recites the step of removing the polymeric residue by subjecting the semiconductor wafer to a wet etch chemistry. These advantageously claimed features are not taught or suggested by the patent granted to Kropewnicki et al. The Appellants submit that Kropewnicki et al. teaches a plasma clean process (column 2 lines 1-44); but not a wet clean process a low-k dielectric environment as advantageously claimed.

The Appellants respectfully traverse the statement in the Office Action (page 3) that Kropewnicki et al. teaches the use of wet etch chemistry for removing the polymeric residue. The Appellants submit that if Kropewnicki et al. taught the step of subjecting the wafer to a wet etch chemistry then the Examiner should be able to point to such a step in the teachings of the invention contained in the Description section of the Specification – instead of referencing just the Background section (where historical methods of wafer cleaning is discussed). If the Examiner is proposing that the Background section anticipates the Appellants' claimed invention, then the Appellants submit that the Background



section does not teach any wet clean process in enough detail to be enabling, and definitely does not teach any wet clean process in a low-k dielectric environment as advantageously claimed (i.e. semiconductor wafers containing low-k dielectrics are never mentioned in the Background section). The Appellants note that wet cleaning alone is not new in the art and not claimed. Rather, the Appellants claim a wet clean process to remove polymeric residue from low-k materials after the bulk photoresist has been removed by a plasma process.

Moreover, Kropewnicki et al. teaches away from the use of wet cleans (col. 1, lines 48-58) while teaching the desirability of the use of a dry clean process (col. 1, line 66 through col. 2, line 44). Specifically, Kropewnicki et al. considers the wet clean process undesirable; stating (column 1 lines 44-57) that the wet clean process requires a solvent that is costly and hazardous to the environment, contributes to lower yield because the substrate is contaminated in the transferring operation, and oxidizes contact/junction points. Furthermore, the Appellants submit that the EKC 265 solvent listed in the cited portion of the Kropewnicki et al. patent (e.g. column 1 line 46) is not capable of removing the polymeric residue on the first material of Claim 30. Specifically, the MSDS for EKC 265 reveals that it contains 2-(2-Aminoethoxy) ethanol plus hydroxylamine plus catechol. Therefore, EKC 265 is very inferior to the advantageously claimed

mixture at removing the type of polymer found on wafers after dielectric etch and resist removal.

Furthermore, the Kropewnicki et al. patent describes the use of a mostly O<sub>2</sub> plasma for resist and residue removal (column 10 lines 36-41; see also column 6 lines 56-58 and 67, column 7 lines 1, 29-30, 46, and 51, column 8 lines 63-64, column 9 lines 7, 54-55, 57, and 64-67, column 10 lines 23-25, 45-46, and 62-64, column 11 lines 3-4 and 7-9). Therefore, Kropewnicki et al. teaches away from the advantageously claimed invention that explicitly excludes the use of any oxygen (see the Appellants' Specification, page 10 line 7). As described by the Appellants in the Specification (page 2 line 29 to page 3 line 14), the cleaning chemistries taught by Kropewnicki et al. would be harmful when used in applications with exposed low-k dielectrics, due to the reaction of the O<sub>2</sub> plasma with the low-k material.

In addition, the Appellants respectfully traverse the statement in the Office Action (page 3) that Kropewnicki et al. teaches the step of subjecting the semiconductor wafer to a plasma which includes hydrogen. The Appellants submit that Kropewnicki et al. teaches the use of an additive gas that contains H but Kropewnicki et al. does not list H<sub>2</sub> as a requirement for his gas mixture (column 6 lines 58-59, column 7 lines 2, 7-34, 47, and 52, column 9 lines 2-4, column 10 lines 57-60).

The Appellants note that Kropewnicki et al. describes the use of an etching chamber to remove the photoresist and post etch and ash polymeric residues (i.e. col. 2, lines 36-44). In addition, Kropewnicki et al requires biasing of the wafer (col. 2, line 22). The Appellants submit that the Kropewnicki et al. process produces substantial damage to low-k dielectric material. The Appellants downstream plasma tool (page 9 lines 13 – 17) operates in a completely different regime that includes higher process pressure, much higher gas flows, much higher temperatures, and no biasing of the wafer.

For these reasons, the Appellants respectfully assert that Claim 60 is patentable over Kropewnicki et al.

**Issue 2 - Whether Claims 1, 5-13 and 31-39 are unpatentable under 35 U.S.C. §103(a) over the patent granted to Kropewnicki et al. (U.S. Pat. No. 6,440,864) in view of the patent granted to Torek et al. (U.S. Pat. No. 6,562,726).**

Claim 1 positively recites the step of removing the polymeric residue by subjecting the semiconductor wafer to a wet etch chemistry. In addition, Claim 1 positively recites subjecting the semiconductor wafer to a plasma annealing step.

These advantageously claimed features are not taught or suggested by the patent granted to Kropewnicki et al. The Appellants submit that Kropewnicki et al. teaches a plasma clean process (column 2 lines 1-44); but not a wet clean process in a low-k dielectric environment as advantageously claimed. In addition, the Appellants submit the Examiner has not, and indeed cannot, provide art that teaches the advantageously claimed plasma annealing in a low-k environment. Therefore the Appellants respectfully traverse the statement in the Office Action (page 4) that "it would have been obvious to a person of ordinary skill in the art to perform an annealing step".

The Appellants respectfully traverse the statement in the Office Action (page 4) that Kropewnicki et al. teaches the use of wet etch chemistry for removing the polymeric residue. The Appellants submit that if Kropewnicki et al. reference in the Background section to the general process of wet cleans is not an enabling teaching of wet etch of polymeric residue on low-k dielectric material, as advantageously claimed. Moreover, Kropewnicki et al. teaches away from the use of wet cleans (col. 1, lines 48-58) while teaching the desirability of the use of a dry clean process (col. 1, line 66 through col. 2, line 44). Specifically, Kropewnicki et al. considers the wet clean process undesirable; stating (column 1 lines 44-57) that the wet clean process requires a solvent that is costly and hazardous to the environment, contributes to lower yield because the substrate is contaminated in the transferring operation, and

oxidizes contact/junction points. Furthermore, the Appellants submit that the EKC 265 solvent listed in column 1 line 46 is not capable of removing the polymeric residue on the first material of Claim 30 (the Appellants tested EKC and saw no residue removal – according to scanning electron micrographs - for the materials described in the Specification and claimed). Specifically, the MSDS for EKC 265 reveals that it contains 2-(2-Aminoethoxy) ethanol plus hydroxylamine plus catechol. Therefore, EKC 265 is very inferior to the advantageously claimed mixture at removing the type of polymer found on wafers after dielectric etch and resist removal.

Furthermore, the Kropewnicki et al. patent describes the use of a mostly O<sub>2</sub> plasma for resist and residue removal (column 10 lines 36-41; see also column 6 lines 56-58 and 67, column 7 lines 1, 29-30, 46, and 51, column 8 lines 63-64, column 9 lines 7, 54-55, 57, and 64-67, column 10 lines 23-25, 45-46, and 62-64, column 11 lines 3-4 and 7-9). Therefore, Kropewnicki et al. teaches away from the advantageously claimed invention that explicitly excludes the use of any oxygen (note the absence of oxygen in the Appellants' claims and see also the Appellants' Specification on page 10 line 7). As described by the Appellants in the Specification (page 2 line 29 to page 3 line 14), the cleaning chemistries taught by Kropewnicki et al. would be harmful when used in applications with exposed low-k dielectrics, due to the reaction of the O<sub>2</sub> plasma with the low-k material.

In addition, the Appellants respectfully traverse the statement in the Office Action (page 4) that Kropewnicki et al. teaches the step of subjecting the semiconductor wafer to a plasma which includes hydrogen. The Appellants submit that Kropewnicki et al. teaches the use of an additive gas that contains H but Kropewnicki et al. does not list H<sub>2</sub> in his gas mixture (column 6 lines 58-59, column 7 lines 2, 7-34, 47, and 52, column 9 lines 2-4, column 10 lines 57-60).

The Appellants note that Kropewnicki et al. describes the use of an etching chamber to remove the photoresist and post etch and ash polymeric residues (i.e. col. 2, lines 36-44). In addition, Kropewnicki et al requires biasing of the wafer (col. 2, line 22). The Appellants submit that the Kropewnicki et al. process produces substantial damage to low-k dielectric material. The Appellants downstream plasma tool (page 9 lines 13 – 17) operates in a completely different regime that includes higher process pressure, much higher gas flows, much higher temperatures, and no biasing of the wafer.

The Appellants respectfully traverse the statement in the Office Action (page 5) that “it would have been obvious to a person of ordinary skill in the art to perform an annealing step.” The Appellants question why there is no art cited in the Office Action which supports the Examiner’s claim. The Appellants submit that it is because it was not obvious “at the time the invention was made” (Office Action, page 4) to perform an annealing step after H-plasma resist removal and

wet clean, as advantageously claimed. Indeed, before the use of low-k materials, there was no issue with fluid being retained inside of etched features (making a plasma anneal step unnecessary and therefore adding unnecessarily to the cost of wafer fabrication). In fact, it took the Appellants a long time to analyze the low-k fabrication problems that resulted in the plasma anneal inventive step.

For these reasons, the Appellants respectfully assert that Claim 1 is patentable over Kropewnicki et al.

Claim 7 is dependent on Claim 1 and is therefore allowable for the same reasons that Claim 1 is allowable. Furthermore, Claim 7 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claim 1, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 7 further specifies the additional limitation that the step of removing polymeric residue comprises subjecting the semiconductor wafer to a combination of dilute hydrofluoric acid and an organic acid. The Appellants respectfully traverse the assertion in the Office Action (page 5) that Torek et al. teaches the advantageously claimed wet etch chemistry. The Appellants submit that a person of ordinary skill in the art would not use the Torek et al. teachings in the advantageously claimed method because Torek et al. is silent as to the nature of the plasma clean before the wet clean (column 3 lines 28-30, column 4 lines 25-32) and that information is critical to the issue of wet clean effectiveness and the

Appellants' invention. For example, Torek et al. teaches away from Claim 7 when Torek et al. teaches that the clean should have three or more components (column 3 lines 46-48, column 5 lines 43-45). The wet clean process of Torek et al is mainly composed of propylene glycol. In addition, Torek et al. specifically states that water should be a minimum component (column 6 lines 24-25). Therefore, the Appellants strongly traverse the characterization of Torek et al.'s solution as "dilute hydrofluoric acid". Unlike Torek et al., the Appellants Claims 6-13 (supported on page 10 of the Appellant's Specification) specifically teach the use of a solution that is much more dilute than Torek et al. Moreover, the Appellants respectfully traverse the statement in the Office Action that it would be obvious to combine the teachings of Torek et al. with Kropewnicki et al. because a person of ordinary skill in the art would not combine a wet clean of HF plus organic acid (Torek et al.) with EKC (Kropewnicki et al.).

Therefore, Claim 7 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 8 is dependent on Claim 7 and is therefore allowable for the same reasons that Claims 1 and 7 are allowable. Furthermore, Claim 8 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 1 and 7, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 8 further specifies the additional



limitation that the organic acid comprises dilute citric acid. The Appellants respectfully traverse the assertion in the Office Action (page 5) that Torek et al. teaches the advantageously claimed wet etch chemistry. The Appellants submit that a person of ordinary skill in the art would not use the Torek et al. teachings in the advantageously claimed method because Torek et al. is silent as to the nature of the plasma clean before the wet clean (column 3 lines 28-30, column 4 lines 25-32) and that information is critical to the issue of wet clean effectiveness and the Appellants' invention. For example, Torek et al. teaches away from Claim 7 when Torek et al. teaches that the clean should have three or more components (column 3 lines 46-48, column 5 lines 43-45). The wet clean process of Torek et al is mainly composed of propylene glycol. In addition, Torek et al. specifically states that water should be a minimum component (column 6 lines 24-25). Therefore, the Appellants strongly traverse the characterization of Torek et al.'s solution as "dilute hydrofluoric acid". Unlike Torek et al., the Appellants Claims 6-13 (supported on page 10 of the Appellant's Specification) specifically teach the use of a solution that is much more dilute than Torek et al. Moreover, the Appellants respectfully traverse the statement in the Office Action that it would be obvious to combine the teachings of Torek et al. with Kropewnicki et al. because a person of ordinary skill in the art would not combine a wet clean of HF plus organic acid (Torek et al.) with EKC (Kropewnicki et al.).

Therefore, Claim 8 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 9 is dependent on Claim 8 and is therefore allowable for the same reasons that Claims 1, 7 and 8 are allowable. Furthermore, Claim 9 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 1, 7 and 8, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 9 further specifies the additional limitation that the dilute citric acid is diluted with deionized water at a ratio between 1:50 to 1:250. The Appellants respectfully traverse the assertion in the Office Action (page 5) that Torek et al. teaches the advantageously claimed wet etch chemistry. The Appellants submit that a person of ordinary skill in the art would not use the Torek et al. teachings in the advantageously claimed method because Torek et al. is silent as to the nature of the plasma clean before the wet clean (column 3 lines 28-30, column 4 lines 25-32) and that information is critical to the issue of wet clean effectiveness and the Appellants' invention. For example, Torek et al. teaches away from Claim 9 when Torek et al. teaches that citric acid is optional (column 6 lines 54-55). For another example, Torek et al. teaches away from Claim 7 when Torek et al. teaches that the clean should have three or more components (column 3 lines 46-48, column 5 lines 43-45). The wet clean process of Torek et al is mainly composed of propylene glycol. In addition, Torek et al. specifically states that water should be a minimum component (column 6 lines 24-

25). Therefore, the Appellants strongly traverse the characterization of Torek et al.'s solution as "dilute hydrofluoric acid". Unlike Torek et al., the Appellants Claims 6-13 (supported on page 10 of the Appellant's Specification) specifically teach the use of a solution that is much more dilute than Torek et al. Moreover, the Appellants respectfully traverse the statement in the Office Action that it would be obvious to combine the teachings of Torek et al. with Kropewnicki et al. because a person of ordinary skill in the art would not combine a wet clean of HF plus organic acid (Torek et al.) with EKC (Kropewnicki et al.).

Therefore, Claim 9 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 10 is dependent on Claim 7 and is therefore allowable for the same reasons that Claims 1 and 7 are allowable. Furthermore, Claim 10 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 1 and 7, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 10 further specifies the additional limitation that the organic acid comprises dilute acetic acid. The Appellants respectfully traverse the assertion in the Office Action (page 5) that Torek et al. teaches the advantageously claimed wet etch chemistry. The Appellants submit that a person of ordinary skill in the art would not use the Torek et al. teachings in the advantageously claimed method because Torek et al. is silent as to the nature

of the plasma clean before the wet clean (column 3 lines 28-30, column 4 lines 25-32) and that information is critical to the issue of wet clean effectiveness and the Appellants' invention. For example, Torek et al. teaches away from Claim 7 when Torek et al. teaches that the clean should have three or more components (column 3 lines 46-48, column 5 lines 43-45). The wet clean process of Torek et al is mainly composed of propylene glycol. In addition, Torek et al. specifically states that water should be a minimum component (column 6 lines 24-25). Therefore, the Appellants strongly traverse the characterization of Torek et al.'s solution as "dilute hydrofluoric acid". Unlike Torek et al., the Appellants Claims 6-13 (supported on page 10 of the Appellant's Specification) specifically teach the use of a solution that is much more dilute than Torek et al. Moreover, the Appellants respectfully traverse the statement in the Office Action that it would be obvious to combine the teachings of Torek et al. with Kropewnicki et al. because a person of ordinary skill in the art would not combine a wet clean of HF plus organic acid (Torek et al.) with EKC (Kropewnicki et al.).

Therefore, Claim 10 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 11 is dependent on Claim 8 and is therefore allowable for the same reasons that Claims 1, 7 and 8 are allowable. Furthermore, Claim 11 is allowable on its own merits because it recites additional features of the invention that, in

combination with the limitations of Claims 1, 7 and 8, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 11 further specifies the additional limitation that the dilute citric acid is diluted with deionized water at a ratio on the order of 1:200. The Appellants respectfully traverse the assertion in the Office Action (page 5) that Torek et al. teaches the advantageously claimed wet etch chemistry. The Appellants submit that a person of ordinary skill in the art would not use the Torek et al. teachings in the advantageously claimed method because Torek et al. is silent as to the nature of the plasma clean before the wet clean (column 3 lines 28-30, column 4 lines 25-32) and that information is critical to the issue of wet clean effectiveness and the Appellants' invention. For example, Torek et al. teaches away from Claim 9 when Torek et al. teaches that citric acid is optional (column 6 lines 54-55). For another example, Torek et al. teaches away from Claim 7 when Torek et al. teaches that the clean should have three or more components (column 3 lines 46-48, column 5 lines 43-45). The wet clean process of Torek et al is mainly composed of propylene glycol. In addition, Torek et al. specifically states that water should be a minimum component (column 6 lines 24-25). Therefore, the Appellants strongly traverse the characterization of Torek et al.'s solution as "dilute hydrofluoric acid". Unlike Torek et al., the Appellants Claims 6-13 (supported on page 10 of the Appellant's Specification) specifically teach the use of a solution that is much more dilute than Torek et al. Moreover, the Appellants respectfully traverse the statement in the Office Action that it would be obvious to combine the teachings of Torek et al. with Kropewnicki et al.

because a person of ordinary skill in the art would not combine a wet clean of HF plus organic acid (Torek et al.) with EKC (Kropewnicki et al.).

Therefore, Claim 11 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 12 is dependent on Claim 7 and is therefore allowable for the same reasons that Claims 1 and 7 are allowable. Furthermore, Claim 12 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 1 and 7, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 12 further specifies the additional limitation that the organic acid comprises oxalic acid. The Appellants respectfully traverse the assertion in the Office Action (page 5) that Torek et al. teaches the advantageously claimed wet etch chemistry. The Appellants submit that a person of ordinary skill in the art would not use the Torek et al. teachings in the advantageously claimed method because Torek et al. is silent as to the nature of the plasma clean before the wet clean (column 3 lines 28-30, column 4 lines 25-32) and that information is critical to the issue of wet clean effectiveness and the Appellants' invention. For example, Torek et al. teaches away from Claim 7 when Torek et al. teaches that the clean should have three or more components (column 3 lines 46-48, column 5 lines 43-45). The wet clean process of Torek et al is mainly composed of propylene glycol. In addition, Torek et al. specifically states

that water should be a minimum component (column 6 lines 24-25). Therefore, the Appellants strongly traverse the characterization of Torek et al.'s solution as "dilute hydrofluoric acid". Unlike Torek et al., the Appellants Claims 6-13 (supported on page 10 of the Appellant's Specification) specifically teach the use of a solution that is much more dilute than Torek et al. Moreover, the Appellants respectfully traverse the statement in the Office Action that it would be obvious to combine the teachings of Torek et al. with Kropewnicki et al. because a person of ordinary skill in the art would not combine a wet clean of HF plus organic acid (Torek et al.) with EKC (Kropewnicki et al.).

Therefore, Claim 12 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 13 is dependent on Claim 7 and is therefore allowable for the same reasons that Claims 1 and 7 are allowable. Furthermore, Claim 13 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 1 and 7, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 13 further specifies the additional limitation that the dilute hydrofluoric acid is diluted with deionized water at a ratio between 1:500 to 1:1,000. The Appellants respectfully traverse the assertion in the Office Action (page 5) that Torek et al. teaches the advantageously claimed wet etch chemistry. The Appellants submit that a person of ordinary skill in the art

would not use the Torek et al. teachings in the advantageously claimed method because Torek et al. is silent as to the nature of the plasma clean before the wet clean (column 3 lines 28-30, column 4 lines 25-32) and that information is critical to the issue of wet clean effectiveness and the Appellants' invention. For example, Torek et al. teaches away from Claim 7 when Torek et al. teaches that the clean should have three or more components (column 3 lines 46-48, column 5 lines 43-45). The wet clean process of Torek et al is mainly composed of propylene glycol. In addition, Torek et al. specifically states that water should be a minimum component (column 6 lines 24-25). Therefore, the Appellants strongly traverse the characterization of Torek et al.'s solution as "dilute hydrofluoric acid". Unlike Torek et al., the Appellants Claims 6-13 (supported on page 10 of the Appellant's Specification) specifically teach the use of a solution that is much more dilute than Torek et al. Moreover, the Appellants respectfully traverse the statement in the Office Action that it would be obvious to combine the teachings of Torek et al. with Kropewnicki et al. because a person of ordinary skill in the art would not combine a wet clean of HF plus organic acid (Torek et al.) with EKC (Kropewnicki et al.).

Therefore, Claim 13 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 31 is dependent on Claim 30 and is therefore allowable for the same reasons that Claim 30 is allowable. Furthermore, Claim 31 is allowable on its own



merits because it recites additional features of the invention that, in combination with the limitations of Claim 30, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 31 further specifies the additional limitation that the step of removing polymeric residue comprises subjecting the semiconductor wafer to a combination of dilute hydrofluoric acid and an organic acid. The Appellants respectfully traverse the assertion in the Office Action (page 5) that Torek et al. teaches the advantageously claimed wet etch chemistry. The Appellants submit that a person of ordinary skill in the art would not use the Torek et al. teachings in the advantageously claimed method because Torek et al. is silent as to the nature of the plasma clean before the wet clean (column 3 lines 28-30, column 4 lines 25-32) and that information is critical to the issue of wet clean effectiveness and the Appellants' invention. For example, Torek et al. teaches away from Claim 31 when Torek et al. teaches that the clean should have three or more components (column 3 lines 46-48, column 5 lines 43-45). The wet clean process of Torek et al is mainly composed of propylene glycol. In addition, Torek et al. specifically states that water should be a minimum component (column 6 lines 24-25). Therefore, the Appellants strongly traverse the characterization of Torek et al.'s solution as "dilute hydrofluoric acid". Unlike Torek et al., the Appellants Claims 6-13 (supported on page 10 of the Appellant's Specification) specifically teach the use of a solution that is much more dilute than Torek et al. Moreover, the Appellants respectfully traverse the statement in the Office Action that it would be obvious to combine the teachings of Torek et al. with Kropewnicki et al. because a person of

ordinary skill in the art would not combine a wet clean of HF plus organic acid (Torek et al.) with EKC (Kropewnicki et al.).

Therefore, Claim 31 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 32 is dependent on Claim 31 and is therefore allowable for the same reasons that Claims 30 and 31 are allowable. Furthermore, Claim 32 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 30 and 31, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 32 further specifies the additional limitation that the organic acid comprises dilute citric acid. The Appellants submit that Torek et al. teaches away from Claim 32 when Torek et al. teaches that citric acid is optional (column 6 lines 54-55). The Appellants respectfully traverse the assertion in the Office Action (page 5) that Torek et al. teaches the advantageously claimed wet etch chemistry. The Appellants submit that a person of ordinary skill in the art would not use the Torek et al. teachings in the advantageously claimed method because Torek et al. is silent as to the nature of the plasma clean before the wet clean (column 3 lines 28-30, column 4 lines 25-32) and that information is critical to the issue of wet clean effectiveness and the Appellants' invention. For example, Torek et al. teaches away from Claim 31 when Torek et al. teaches that the clean should have three or more components (column

3 lines 46-48, column 5 lines 43-45). The wet clean process of Torek et al is mainly composed of propylene glycol. In addition, Torek et al. specifically states that water should be a minimum component (column 6 lines 24-25). Therefore, the Appellants strongly traverse the characterization of Torek et al.'s solution as "dilute hydrofluoric acid". Unlike Torek et al., the Appellants Claims 6-13 (supported on page 10 of the Appellant's Specification) specifically teach the use of a solution that is much more dilute than Torek et al. Moreover, the Appellants respectfully traverse the statement in the Office Action that it would be obvious to combine the teachings of Torek et al. with Kropewnicki et al. because a person of ordinary skill in the art would not combine a wet clean of HF plus organic acid (Torek et al.) with EKC (Kropewnicki et al.).

Therefore, Claim 32 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 33 is dependent on Claim 31 and is therefore allowable for the same reasons that Claims 30 and 31 are allowable. Furthermore, Claim 33 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 30 and 31, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 33 further specifies the additional limitation that the organic acid comprises dilute acetic acid. The Appellants respectfully traverse the assertion in the Office Action (page 5) that

Torek et al. teaches the advantageously claimed wet etch chemistry. The Appellants submit that a person of ordinary skill in the art would not use the Torek et al. teachings in the advantageously claimed method because Torek et al. is silent as to the nature of the plasma clean before the wet clean (column 3 lines 28-30, column 4 lines 25-32) and that information is critical to the issue of wet clean effectiveness and the Appellants' invention. For example, Torek et al. teaches away from Claim 31 when Torek et al. teaches that the clean should have three or more components (column 3 lines 46-48, column 5 lines 43-45). The wet clean process of Torek et al is mainly composed of propylene glycol. In addition, Torek et al. specifically states that water should be a minimum component (column 6 lines 24-25). Therefore, the Appellants strongly traverse the characterization of Torek et al.'s solution as "dilute hydrofluoric acid". Unlike Torek et al., the Appellants Claims 6-13 (supported on page 10 of the Appellant's Specification) specifically teach the use of a solution that is much more dilute than Torek et al. Moreover, the Appellants respectfully traverse the statement in the Office Action that it would be obvious to combine the teachings of Torek et al. with Kropewnicki et al. because a person of ordinary skill in the art would not combine a wet clean of HF plus organic acid (Torek et al.) with EKC (Kropewnicki et al.).

Therefore, Claim 33 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 34 is dependent on Claim 31 and is therefore allowable for the same reasons that Claims 30 and 31 are allowable. Furthermore, Claim 34 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 30 and 31, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 34 further specifies the additional limitation that the organic acid comprises oxalic acid. The Appellants respectfully traverse the assertion in the Office Action (page 5) that Torek et al. teaches the advantageously claimed wet etch chemistry. The Appellants submit that a person of ordinary skill in the art would not use the Torek et al. teachings in the advantageously claimed method because Torek et al. is silent as to the nature of the plasma clean before the wet clean (column 3 lines 28-30, column 4 lines 25-32) and that information is critical to the issue of wet clean effectiveness and the Appellants' invention. For example, Torek et al. teaches away from Claim 31 when Torek et al. teaches that the clean should have three or more components (column 3 lines 46-48, column 5 lines 43-45). The wet clean process of Torek et al is mainly composed of propylene glycol. In addition, Torek et al. specifically states that water should be a minimum component (column 6 lines 24-25). Therefore, the Appellants strongly traverse the characterization of Torek et al.'s solution as "dilute hydrofluoric acid". Unlike Torek et al., the Appellants Claims 6-13 (supported on page 10 of the Appellant's Specification) specifically teach the use of a solution that is much more dilute than Torek et al. Moreover, the Appellants respectfully traverse the statement in the Office Action that it would be obvious to

combine the teachings of Torek et al. with Kropewnicki et al. because a person of ordinary skill in the art would not combine a wet clean of HF plus organic acid (Torek et al.) with EKC (Kropewnicki et al.).

Therefore, Claim 34 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 35 is dependent on Claim 30 and is therefore allowable for the same reasons that Claim 30 is allowable. Furthermore, Claim 35 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claim 30, are not taught nor suggested by the patent granted to Torek et al. Namely, Claim 35 further specifies the additional limitation that the hydrogen is provided from a hydrogen source selected from a group consisting of  $H_2$ ,  $NH_3$ ,  $N_2H_2$ ,  $H_2S$ , and  $CH_4$ . The Appellants respectfully traverse the assertion in the Office Action (page 5) that Kropewnicki et al. teaches the advantageously claimed use of hydrogen plasma on low-k dielectric materials before a wet clean process. The Appellants submit that Kropewnicki et al. teaches a primarily oxygen plasma process (column 11 lines 2-4) and Kropewnicki et al. does not teach the use of a wet clean process in a low-k dielectric environment.

Therefore, Claim 35 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 5 is listed under this 35 U.S.C. §103(a) rejection; however, there are no rejections directed toward Claim 5. Claim 5 is dependent on Claim 1 and is therefore allowable for the same reasons that Claim 1 is allowable. Furthermore, Claim 5 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claim 1, are not taught nor suggested by the patents granted to Kropewnicki et al. and Torek et al. Namely, Claim 5 further specifies the additional limitation that the plasma annealing step comprises subjecting the semiconductor wafer to a plasma which incorporates a mixture of hydrogen and nitrogen.

Therefore, Claim 5 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 6 is listed under this 35 U.S.C. §103(a) rejection; however, there are no rejections directed toward Claim 6. Claim 6 is dependent on Claim 5 and is therefore allowable for the same reasons that Claims 1 and 5 are allowable. Furthermore, Claim 6 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 1 and 5, are not taught nor suggested by the patents granted to Kropewnicki et al. and Torek et al. Namely, Claim 6 further specifies the additional limitation that the mixture includes no more than 40% nitrogen.

Therefore, Claim 6 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 36 is listed under this 35 U.S.C. §103(a) rejection; however, there are no rejections directed toward Claim 36. Claim 36 is dependent on Claim 30 and is therefore allowable for the same reasons that Claim 30 is allowable. Furthermore, Claim 36 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claim 30, are not taught nor suggested by the patents granted to Kropewnicki et al. and Torek et al. Namely, Claim 36 further specifies the additional limitations that the gas comprises a mixture of gases and the mixture includes at least 50% hydrogen.

Therefore, Claim 36 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 37 is listed under this 35 U.S.C. §103(a) rejection; however, there are no rejections directed toward Claim 37. Claim 37 is dependent on Claim 36 and is therefore allowable for the same reasons that Claims 30 and 36 are allowable. Furthermore, Claim 37 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 30 and 36, are not taught nor suggested by the patents granted to Kropewnicki et al. and



Torek et al. Namely, Claim 37 further specifies the additional limitation that the mixture of gases further includes a diluent.

Therefore, Claim 37 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 38 is listed under this 35 U.S.C. §103(a) rejection; however, there are no rejections directed toward Claim 38. Claim 38 is dependent on Claim 37 and is therefore allowable for the same reasons that Claims 30, 36 and 37 are allowable. Furthermore, Claim 38 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 30, 36 and 37, are not taught nor suggested by the patents granted to Kropewnicki et al. and Torek et al. Namely, Claim 38 further specifies the additional limitation that the diluent is selected from a group consisting of nitrogen, argon, helium, neon, and xenon.

Therefore, Claim 38 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

Claim 39 is listed under this 35 U.S.C. §103(a) rejection; however, there are no rejections directed toward Claim 39. Claim 39 is dependent on Claim 37 and is therefore allowable for the same reasons that Claims 30, 36 and 37 are allowable.

Furthermore, Claim 39 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 30, 36 and 37, are not taught nor suggested by the patents granted to Kropewnicki et al. and Torek et al. Namely, Claim 39 further specifies the additional limitations that the diluent comprises nitrogen and the mixture comprises 20% or less of the nitrogen.

Therefore, Claim 39 is patentable over the patents granted to Kropewnicki et al. and Torek et al.

**Issue 3 - Whether Claims 36-39 are unpatentable under 35 U.S.C. §103(a) over the patents granted to Kropewnicki et al. (U.S. Pat. No. 6,440,864) and Torek et al. (U.S. Pat. No. 6,562,726) as applied to Claim 30, and further in view of the patent granted to Hillyer et al. (U.S. Pat. No. 6,613,681).**

Claim 36 is dependent on Claim 30 and is therefore allowable for the same reasons that Claim 30 is allowable. Furthermore, Claim 36 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claim 30, are not taught nor suggested by the patents granted to Kropewnicki et al., Torek et al., and Hillyer et al. Namely, Claim 36

further specifies the additional limitations that the gas comprises a mixture of gases and the mixture includes at least 50% hydrogen.

The Appellants traverse the statement in the Office Action (pages 5-6) that it would be logical to combine the mixture of Hillyer et al. with the mixture of Kropewnicki et al. The Appellants submit that Hillyer et al. teaches the use of 25-100%  $\text{NH}_3$  (column 4 lines 39-42) but Kropewnicki et al. teaches the use of only small amounts of  $\text{NH}_3$  (column 7 line 22-24). In fact, Kropewnicki et al. states that "it has been further discovered that excessive amounts of  $\text{NH}_3$  addition can adversely affect the cleaning rate" (column 7 lines 14-16).

Hillyer teaches away from the advantageously claimed invention because Hillyer et al. discloses the use of oxygen in the plasma (column 4 lines 14, and 38-43). This is in contrast to the Appellants' teaching that the use of oxygen is excluded (page 10 line 7). In addition, Hillyer et al. teaches the use of a wet clean after the  $\text{NH}_3$  plasma treatment (column 4 lines 54-62). Specifically, Hillyer et al. teaches a cleaning procedure comprised of a plasma resist removal, then plasma residue removal, and then wet clean (to remove the now soluble residues). In contrast, the Appellants teach H-plasma resist removal and then a wet clean. The two cleaning procedures are quite different.

Therefore, Claim 36 is patentable over the patents granted to Kropewnicki et al., Torek et al. and Hillyer et al.

Claim 37 is dependent on Claim 36 and is therefore allowable for the same reasons that Claims 30 and 36 are allowable. Furthermore, Claim 37 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 30 and 36, are not taught nor suggested by the patents granted to Kropewnicki et al., Torek et al., and Hillyer et al. Namely, Claim 37 further specifies the additional limitation that the mixture of gases further includes a diluent.

The Appellants traverse the statement in the Office Action (page 6) that “Hillyer discloses wherein the mixture of gases comprises nitrogen and nitrogen (col. 4, lines 4-53 and Fig. 45)”. The Appellants submit that Hillyer et al. teaches the use of ammonia (column 4 lines 11-12 and 41-42), not nitrogen.

The Appellants traverse the statement in the Office Action (pages 5-6) that it would be logical to combine the mixture of Hillyer et al. with the mixture of Kropewnicki et al. The Appellants submit that Hillyer et al. teaches the use of 25-100%  $\text{NH}_3$  (column 4 lines 39-42) but Kropewnicki et al. teaches the use of only small amounts of  $\text{NH}_3$  (column 7 line 22-24). In fact, Kropewnicki et al. states that

“it has been further discovered that excessive amounts of  $\text{NH}_3$  addition can adversely affect the cleaning rate” (column 7 lines 14-16).

Hillyer teaches away from the advantageously claimed invention because Hillyer et al. discloses the use of oxygen in the plasma (column 4 lines 14, and 38-43). This is in contrast to the Appellants’ teaching that the use of oxygen is excluded (page 10 line 7). In addition, Hillyer et al. teaches the use of a wet clean after the  $\text{NH}_3$  plasma treatment (column 4 lines 54-62). Specifically, Hillyer et al. teaches a cleaning procedure comprised of a plasma resist removal, then plasma residue removal, and then wet clean (to remove the now soluble residues). In contrast, the Appellants teach H-plasma resist removal and then a wet clean. The two cleaning procedures are quite different.

Therefore, Claim 37 is patentable over the patents granted to Kropewnicki et al., Terek et al. and Hillyer et al.

Claim 38 is dependent on Claim 37 and is therefore allowable for the same reasons that Claims 30, 36 and 37 are allowable. Furthermore, Claim 38 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 30, 36 and 37, are not taught nor suggested by the patents granted to Kropewnicki et al., Terek et al., and Hillyer et

al. Namely, Claim 38 further specifies the additional limitation that the diluent is selected from a group consisting of nitrogen, argon, helium, neon, and xenon.

The Appellants traverse the statement in the Office Action (page 6) that “Hillyer discloses wherein the mixture of gases comprises nitrogen and nitrogen (col. 4, lines 4-53 and Fig. 45)”. The Appellants submit that Hillyer et al. teaches the use of ammonia (column 4 lines 11-12 and 41-42), not nitrogen.

The Appellants traverse the statement in the Office Action (pages 5-6) that it would be logical to combine the mixture of Hillyer et al. with the mixture of Kropewnicki et al. The Appellants submit that Hillyer et al. teaches the use of 25-100%  $\text{NH}_3$  (column 4 lines 39-42) but Kropewnicki et al. teaches the use of only small amounts of  $\text{NH}_3$  (column 7 line 22-24). In fact, Kropewnicki et al. states that “it has been further discovered that excessive amounts of  $\text{NH}_3$  addition can adversely affect the cleaning rate” (column 7 lines 14-16).

Hillyer teaches away from the advantageously claimed invention because Hillyer et al. discloses the use of oxygen in the plasma (column 4 lines 14, and 38-43). This is in contrast to the Appellants’ teaching that the use of oxygen is excluded (page 10 line 7). In addition, Hillyer et al. teaches the use of a wet clean after the  $\text{NH}_3$  plasma treatment (column 4 lines 54-62). Specifically, Hillyer et al. teaches a cleaning procedure comprised of a plasma resist removal, then plasma

residue removal, and then wet clean (to remove the now soluble residues). In contrast, the Appellants teach H-plasma resist removal and then a wet clean. The two cleaning procedures are quite different.

Therefore, Claim 38 is patentable over the patents granted to Kropewnicki et al., Torek et al. and Hillyer et al.

Claim 39 is dependent on Claim 37 and is therefore allowable for the same reasons that Claims 30, 36 and 37 are allowable. Furthermore, Claim 39 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claims 30, 36 and 37, are not taught nor suggested by the patents granted to Kropewnicki et al., Torek et al., and Hillyer et al. Namely, Claim 39 further specifies the additional limitations that the diluent comprises nitrogen and the mixture comprises 20% or less of the nitrogen.

The Appellants traverse the statement in the Office Action (page 6) that “Hillyer discloses wherein the mixture of gases comprises nitrogen and nitrogen (col. 4, lines 4-53 and Fig. 45)”. The Appellants submit that Hillyer et al. teaches the use of ammonia (column 4 lines 11-12 and 41-42), not nitrogen.

The Appellants traverse the statement in the Office Action (pages 5-6) that it would be logical to combine the mixture of Hillyer et al. with the mixture of

Kropewnicki et al. The Appellants submit that Hillyer et al. teaches the use of 25-100% NH<sub>3</sub> (column 4 lines 39-42) but Kropewnicki et al. teaches the use of only small amounts of NH<sub>3</sub> (column 7 line 22-24). In fact, Kropewnicki et al. states that "it has been further discovered that excessive amounts of NH<sub>3</sub> addition can adversely affect the cleaning rate" (column 7 lines 14-16).

Hillyer teaches away from the advantageously claimed invention because Hillyer et al. discloses the use of oxygen in the plasma (column 4 lines 14, and 38-43). This is in contrast to the Appellants' teaching that the use of oxygen is excluded (page 10 line 7). In addition, Hillyer et al. teaches the use of a wet clean after the NH<sub>3</sub> plasma treatment (column 4 lines 54-62). Specifically, Hillyer et al. teaches a cleaning procedure comprised of a plasma resist removal, then plasma residue removal, and then wet clean (to remove the now soluble residues). In contrast, the Appellants teach H-plasma resist removal and then a wet clean. The two cleaning procedures are quite different.

Therefore, Claim 39 is patentable over the patents granted to Kropewnicki et al., Torek et al. and Hillyer et al.



**Issue 4 - Whether Claims 61-68 are unpatentable under 35 U.S.C. §103(a) over the patent granted to Kropewnicki et al. (U.S. Pat. No. 6,440,864) in view of the patent granted to Hillyer et al. (U.S. Pat. No. 6,613,681).**

Claim 61 positively recites the step of subjecting the semiconductor wafer to a plasma which incorporates a gas which includes a diluent and at least 50% hydrogen so as to remove the photoresist layer. These advantageously claimed features are not taught or suggested by the patents granted to Kropewnicki et al. or Hillyer et al., either alone or in combination.

The Appellants traverse the statement in the Office Action (page 6) that Kropewnicki et al. teaches the step of subjecting the wafer to a plasma which includes a diluent and hydrogen at column 6 lines 10-65. The Appellants submit that Kropewnicki et al. does not suggest H as a H-source, plus H is not itself sought as an active compound in the gas mixture (column 6 lines 58-59). In addition, Kropewnicki et al. teaches away from the advantageously claimed invention because Kropewnicki et al. teaches the use of additives where H quantities are far less than 50% by volume (column 7 lines 20-25).

Furthermore, the Kropewnicki et al. patent describes the use of a mostly O<sub>2</sub> plasma for resist and residue removal (column 10 lines 36-41; see also column 6

lines 56-58 and 67, column 7 lines 1, 29-30, 46, and 51, column 8 lines 63-64, column 9 lines 7, 54-55, 57, and 64-67, column 10 lines 23-25, 45-46, and 62-64, column 11 lines 3-4 and 7-9). Therefore, Kropewnicki et al. teaches away from the advantageously claimed invention that explicitly excludes the use of any oxygen (see the Appellants' Specification on page 10 line 7). As described by the Appellants in the Specification (page 2 line 29 to page 3 line 14), the cleaning chemistries taught by Kropewnicki et al. would be harmful when used in applications with exposed low-k dielectrics, due to the reaction of the O<sub>2</sub> plasma with the low-k material.

Hillyer et al. discloses the use of oxygen in the plasma (column 4 lines 14, and 38-43). This is in contrast to the Appellants claims (Claims 61-68) and their teaching that the use of oxygen is excluded (page 10 line 7).

In addition, Hillyer et al. teaches the use of a wet clean after the NH<sub>3</sub> plasma treatment (column 4 lines 54-62). Namely, Hillyer et al. teaches a cleaning procedure comprised of a plasma resist removal, then plasma residue removal, and then wet clean (to remove the now soluble residues). In contrast, the Appellants teach H-plasma resist removal, a wet clean, and then a H-plasma anneal. The two cleaning procedures are quite different and result in different surface conditions. In fact, the Appellants submit that it is undesirable to end the process sequence with a wet clean (Hillyer et al.) because of the chance that

volatile components may exist in pockets inside of the porous low-k material – leading to undesirable void formation during the metal deposition step.

Lastly, the Appellants traverse the statement in the Office Action (pages 6-7) that it would be logical to combine the mixture of Hillyer et al. with the mixture of Kropewnicki et al. The Appellants submit that Hillyer et al. teaches the use of 25-100%  $\text{NH}_3$  (column 4 lines 39-42) but Kropewnicki et al. teaches the use of small amounts of  $\text{NH}_3$  (column 7 line 22-24). In fact, Kropewnicki et al. states that “it has been further discovered that excessive amounts of  $\text{NH}_3$  addition can adversely affect the cleaning rate” (column 7 lines 14-16).

Therefore, Claim 61 is patentable over the patents granted to Kropewnicki et al. and Hillyer et al.

Claim 62 is dependent on Claim 61 and is therefore allowable for the same reasons that Claim 61 is allowable. Furthermore, Claim 62 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claim 61, are not taught nor suggested by the patents granted to Kropewnicki et al. Namely, Claim 62 further specifies the additional limitation that the hydrogen is provided from a hydrogen source selected from a group consisting of  $\text{H}_2$ ,  $\text{NH}_3$ ,  $\text{N}_2\text{H}_2$ ,  $\text{H}_2\text{S}$ , and  $\text{CH}_4$ . The Appellants respectfully traverse the assertion in the Office Action (page 5) that Kropewnicki et al. teaches

the advantageously claimed use of hydrogen plasma on low-k dielectric materials before a wet clean process. The Appellants submit that Kropewnicki et al. teaches a primarily oxygen plasma process (column 11 lines 2-4) and Kropewnicki et al. does not teach the use of a wet clean process in a low-k dielectric environment. Furthermore, the cleaning chemistries taught by Kropewnicki et al. would be harmful when used in applications with exposed low-k dielectrics, due to the reaction of the O<sub>2</sub> plasma with the low-k material.

Therefore, Claim 62 is patentable over the patents granted to Kropewnicki et al. and Hillyer et al.

Claim 63 is dependent on Claim 61 and is therefore allowable for the same reasons that Claim 61 is allowable. Furthermore, Claim 63 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claim 61 is not taught nor suggested by the patents granted to Hillyer et al. Namely, Claim 63 further specifies the additional limitation that the diluent is selected from a group consisting of nitrogen, argon, helium, neon, and xenon.

The Appellants traverse the statement in the Office Action (page 7) that "Hillyer discloses wherein the diluent comprises nitrogen and nitrogen (col. 4, lines

4-35 and Fig. 45)". The Appellants submit that Hillyer et al. teaches the use of ammonia (column 4 lines 11-12 and 41-42), not nitrogen.

Therefore, Claim 63 is patentable over the patents granted to Kropewnicki et al. and Hillyer et al.

Claim 64 is dependent on Claim 61 and is therefore allowable for the same reasons that Claim 61 is allowable. Furthermore, Claim 64 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claim 61 is not taught nor suggested by the patents granted to Hillyer et al. Namely, Claim 64 further specifies the additional limitation that the diluent comprises nitrogen and the mixture comprises 20% or less of the nitrogen.

The Appellants traverse the statement in the Office Action (page 7) that "Hillyer discloses wherein the diluent comprises nitrogen and nitrogen (col. 4, lines 4-53 and Fig. 45)". The Appellants submit that Hillyer et al. teaches the use of ammonia (column 4 lines 11-12 and 41-42), not nitrogen.

Therefore, Claim 64 is patentable over the patents granted to Kropewnicki et al. and Hillyer et al.

Claim 65 is dependent on Claim 61 and is therefore allowable for the same reasons that Claim 61 is allowable. Furthermore, Claim 65 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claim 61 is not taught nor suggested by the patents granted to Hillyer et al. Namely, Claim 65 further specifies the additional limitation that the gas includes approximately 80% NH<sub>3</sub> and 20% N<sub>2</sub>.

The Appellants traverse the statement in the Office Action (page 7) that "Hillyer discloses wherein the diluent comprises nitrogen and nitrogen (col. 4, lines 4-53 and Fig. 45)". The Appellants submit that Hillyer et al. teaches the use of ammonia (column 4 lines 11-12 and 41-42), not nitrogen.

Therefore, Claim 65 is patentable over the patents granted to Kropewnicki et al. and Hillyer et al.

Claim 66 is dependent on Claim 61 and is therefore allowable for the same reasons that Claim 61 is allowable. Furthermore, Claim 66 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claim 61, are not taught nor suggested by the patents granted to Kropewnicki et al. Namely, Claim 66 further specifies the additional limitation that the first material comprises a carbon containing material. The Appellants submit that the cleaning chemistries taught by Kropewnicki et al. would

be harmful when used in applications with exposed low-k dielectrics, due to the reaction of the O<sub>2</sub> plasma with the low-k material.

Therefore, Claim 66 is patentable over the patents granted to Kropewnicki et al. and Hillyer et al.

Claim 67 is dependent on Claim 61 and is therefore allowable for the same reasons that Claim 61 is allowable. Furthermore, Claim 67 is allowable on its own merits because it recites additional features of the invention that, in combination with the limitations of Claim 61, are not taught nor suggested by the patents granted to Kropewnicki et al. Namely, Claim 67 further specifies the additional limitation that the first material comprises fluorinated silicon glass. The Appellants submit that the cleaning chemistries taught by Kropewnicki et al. would be harmful when used in applications with exposed low-k dielectrics, due to the reaction of the O<sub>2</sub> plasma with the low-k material.

Therefore, Claim 67 is patentable over the patents granted to Kropewnicki et al. and Hillyer et al.

Claim 68 is dependent on Claim 61 and is therefore allowable for the same reasons that Claim 61 is allowable. Furthermore, Claim 68 is allowable on its own merits because it recites additional features of the invention that, in combination

with the limitations of Claim 61, are not taught nor suggested by the patents granted to Kropewnicki et al. Namely, Claim 68 further specifies the additional limitation that the first material has a dielectric constant less than 2.8. The Appellants submit that the cleaning chemistries taught by Kropewnicki et al. would be harmful when used in applications with exposed low-k dielectrics, due to the reaction of the O<sub>2</sub> plasma with the low-k material.

Therefore, Claim 68 is patentable over the patents granted to Kropewnicki et al. and Hillyer et al.

### **ADDITIONAL ARGUMENTS**

In response to the additional comments on pages 8-9 of the Advisory Action the Appellants reiterate the following points.

First, the Examiner states that Kropewnicki et al. teaches the Appellants' wet clean process in column 1 lines 44-45 (Office Action, page 8). The Appellants submit that the Background section of Kropewnicki et al. does not contain an enabling teaching of a wet clean process – much less an enabling wet clean process for low-k dielectric materials. In fact, low-k materials are not even mentioned in the Background section of Kropewnicki et al. The Appellants note



that the wet cleaning process by itself is not new in the art and is not claimed (wet chemical removal was widely used in the semiconductor industry before plasmas were available and before anyone thought of applying the use of plasmas to photoresist removal, post etch resist, or post etch polymer removal). The removal of polymeric material from a substrate that is itself partially organic is not an easy task since many wet chemistries (and plasma processes) will strip the organic portions of the dielectric material and thereby render it no longer a low-k material. Moreover, the use of EKC 265 - as taught in the Background section of Kropewnicki et al. cited by the Examiner – was found to be ineffective by Appellants in their tests for cleaning residues off of low-k materials following a plasma process.

Second, the Examiner states that “annealing after a wet clean to evaporate/remove the etchant solution remaining on the surface of the wafer therefore reducing time for next conductor depositing step, and also eliminating contamination the wafer” (Office Action, page 8). The Appellants submit that when SiO<sub>2</sub> was the material used for the dielectric layer in semiconductor manufacturing, the via openings were quite large; therefore, there was no issue with fluids being retained inside the etched features that later become trapped when the next metal layer was deposited. The Appellants submit that an anneal step in that situation is unnecessary and only adds to the cost of the finished wafer. The Appellants never observed any issues with wet chemicals being

absorbed into any of the prior art SiO<sub>2</sub> dielectric materials. Therefore Appellant are not surprised that the Examiner cannot point to any art to back up the statements in the Office Action rejecting the Appellants' annealing step. Only after intensive analysis of issues experienced with the use of (porous) low-k materials and the associated metal voiding did the Appellants invent the hydrogen plasma annealing step.

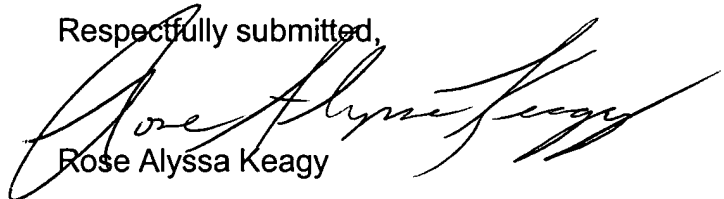
Third, the Examiner states that Torek et al. provides motivation to combine with Kropewnicki et al. (Office Action, pages 8-9). The Appellants submit that Kropewnicki et al. only mentions wet cleaning in a broad manner in the Background section (right before stating that the wet clean process is undesirable at column 1 lines 44-57). The Appellants also submit that the wet clean process of Torek et al. is considerably different in formulation from the Appellants' process. Therefore, even if Torek et al. was combined with Kropewnicki et al., the resultant combination would not teach or suggest the advantageously claimed invention. Specifically, the solution taught by Torek et al. is mostly composed of components other than water. In fact, in column 6 lines 24-25, Torek et al states "it is preferred, however, that the water content of the conditioning solution be as low as possible." Based on the typical values provided in column 6 lines 30-53, Torek et al.'s solution is less than 1% water. Namely, Torek et al.'s first formulation is 80-99% propylene glycol with HF, HCl, and citric acids. His second formulation is 90-98% propylene glycol with HF,

HCl, and citric acids. His third formulation is 97.5% propylene glycol with HF, HCl, and citric acids. Conversely, the Appellants' HF solution is 49 weight % HF diluted with deionized water from 1:500 to 1:1000, with 1:625 preferred. Furthermore, the Appellant's citric acid is 30 weight % diluted with deionized water from 1:50 to 1:250, with 1:50 preferred. (See Appellants' Specification, page 10.) Therefore, the Appellants solution is much more dilute than the solution taught by Torek et al. Moreover, the Appellants have proven that their dilute solution is not harmful to low-k materials.

### CONCLUSION

For the reasons stated above, the Appellants respectfully contend that each claim is patentable. Therefore, the reversal of all rejections is courteously solicited.

Respectfully submitted,

A handwritten signature in black ink, appearing to read "Rose Alyssa Keagy", written over the typed name.

Rose Alyssa Keagy

Attorney for Appellants, Reg. No. 35,095

Texas Instruments Incorporated

PO BOX 655474, M/S 3999

Dallas, TX 75265

Telephone: 972/917-4167, FAX: 972/917-4409/4418

## **APPENDIX**

### **Claims on Appeal**

1. A method of fabricating an electronic device formed on a semiconductor wafer, comprising the steps of:

forming a layer of a first material in a fixed position relative to the wafer, wherein the first material has a dielectric constant less than 3.6;

forming a photoresist layer in a fixed position relative to the layer of the first material;

forming at least one void through the layer of the first material in response to the photoresist layer, thereby forming a polymeric residue in response to the photoresist layer;

subjecting the semiconductor wafer to a plasma which incorporates a gas which includes hydrogen so as to remove the photoresist layer; and

removing the polymeric residue, the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a wet etch chemistry and also subjecting the semiconductor wafer to a plasma annealing step.

5. The method of claim 1 wherein the plasma annealing step comprises subjecting the semiconductor wafer to a plasma which incorporates a mixture of hydrogen and nitrogen.

6. The method of claim 5 wherein the mixture includes no more than 40% nitrogen.

7. The method of claim 1 wherein the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a combination of dilute hydrofluoric acid and an organic acid.

8. The method of claim 7 wherein the organic acid comprises dilute citric acid.

9. The method of claim 8 wherein the dilute citric acid is diluted with deionized water at a ratio between 1:50 to 1:250.

10. The method of claim 7 wherein the organic acid comprises dilute acetic acid.

11. The method of claim 8 wherein the dilute acetic acid is diluted with deionized water at a ratio on the order of 1:200.

12. The method of claim 7 wherein the organic acid comprises oxalic acid.

13. The method of claim 7 wherein the dilute hydrofluoric acid is diluted with deionized water at a ratio between 1:500 to 1:1,000.

30. A method of fabricating an electronic device formed on a semiconductor wafer, comprising the steps of:

forming a layer of a first material in a fixed position relative to the wafer, wherein the first material is reactive with oxygen plasma;

forming a photoresist layer in a fixed position relative to the layer of the first material;

forming at least one void through the layer of the first material in response to the photoresist layer, wherein the step of forming at least one void further forms a polymeric residue in response to the photoresist layer;

subjecting the semiconductor wafer to a plasma which incorporates a gas which includes hydrogen so as to remove the photoresist layer; and

removing the polymeric residue by subjecting the semiconductor wafer to a wet etch chemistry.

31. The method of claim 30 wherein the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a combination of dilute hydrofluoric acid and an organic acid.

32. The method of claim 31 wherein the organic acid comprises dilute citric acid.

33. The method of claim 31 wherein the organic acid comprises dilute acetic acid.

34. The method of claim 31 wherein the organic acid comprises dilute oxalic acid.

35. The method of claim 30 wherein the hydrogen is provided from a hydrogen source selected from a group consisting of  $H_2$ ,  $NH_3$ ,  $N_2H_2$ ,  $H_2S$ , and  $CH_4$ .

36. The method of claim 30:

wherein the gas comprises a mixture of gases; and

wherein the mixture includes at least 50% hydrogen.

37. The method of claim 36 wherein the mixture of gases further includes a diluent.

38. The method of claim 37 wherein the diluent is selected from a group consisting of nitrogen, argon, helium, neon, and xenon.

39. The method of claim 37:

wherein the diluent comprises nitrogen; and

wherein the mixture comprises 20% or less of the nitrogen.

60. A method of fabricating an electronic device formed on a semiconductor wafer, comprising the steps of:

forming a layer of a first material in a fixed position relative to the wafer, wherein the first material has a dielectric constant less than 3.6;

forming a photoresist layer in a fixed position relative to the layer of the first material;

forming at least one void through the layer of the first material in response to the photoresist layer, thereby forming a polymeric residue in response to the photoresist layer;

subjecting the semiconductor wafer to a plasma which incorporates a gas which includes hydrogen so as to remove the photoresist layer; and

removing the polymeric residue, the step of removing the polymeric residue comprises subjecting the semiconductor wafer to a wet etch chemistry.



61. A method of fabricating an electronic device formed on a semiconductor wafer, comprising the steps of:

forming a layer of a first material in a fixed position relative to the wafer, wherein the first material has a dielectric constant less than 3.6;

forming a photoresist layer in a fixed position relative to the layer of the first material;

forming at least one void through the layer of the first material in response to the photoresist layer; and

subjecting the semiconductor wafer to a plasma which incorporates a gas which includes a diluent and at least 50% hydrogen so as to remove the photoresist layer.

62. The method of Claim 61 wherein the hydrogen is provided from a hydrogen source selected from a group consisting of  $H_2$ ,  $NH_3$ ,  $N_2H_2$ ,  $H_2S$ , and  $CH_4$ .

63. The method of claim 61 wherein the diluent is selected from a group consisting of nitrogen, argon, helium, neon, and xenon.

64. The method of claim 61:

wherein the diluent comprises nitrogen; and

wherein the mixture comprises 20% or less of the nitrogen.

65. The method of claim 61 wherein the gas includes approximately 80%  $\text{NH}_3$  and 20%  $\text{N}_2$ .

66. The method of claim 61 wherein the first material comprises a carbon containing oxide.

67. The method of claim 61 wherein the first material comprises fluorinated silicon glass.

68. The method of claim 61 wherein the first material has a dielectric constant less than 2.8.